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THE UTILIZATION OF THE BEHAVIORAL SCIENCES IN LONG RANGE FORECASTING AND POLICY PLANNING

Semi-Annual Technical Report No. 3

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I. INTRODUCTION

1.1: Summary of Technical Work to Date. The goals of the project have been the development of forecasting techniques to the point where the impact of alternative U.S. foreign policies toward specific countries can be assessed in alternative strategic environments. As a way of achieving this objective, the Project is developing computer simulations of several Middle-East oil producing nations. In doing this, assumptions about the relations between U.S. policies and policy actions and country and region specific indicators of stability are being expressed in a mathematical language. Results from current ARPA supported basic research efforts are being used to provide a basis for defining and testing the relations between these indicators. In a future phase of the Project, mathematical control theory and (subjective) dynamic programming (augmented with user stated objectives in each country) will be applied to identify "best" mixes of U.S. policy toward each country.

As a substantive target, U.S. relations with Saudi Arabia, Iran, Iraq, Libya, and Algeria are being studied. Thus far the emphasis has been upon Iran and Saudi Arabia. Each country simulation is divided roughly into four modules - an agriculture module, an oil module, a human resources and national accounts module, and a government or "decision-making" module (this structure is shown mathematically in Figure I.1). In order that these simulations have maximal impact upon the policy planning community and in order to take advantage of the knowledge of planners, the simulations are being developed in close interaction with policy planners in both Defense and State Departments.

During the first phase of the contract, the following tasks have been completed.

- Developed and completed preliminary testing of the oil, agriculture, and human resources modules. These modules are described in detail in PTP Working Papers 15,16, and 23.

- The oil and agriculture modules are coded and running interactively on the O.S.U. IBM 370/165.

- To assist in the development and testing of the simulations, working relations have been established with Maj. General W. Y. Smith, Director, Policy Plans and NSC Affairs, OSD/ISA; Tom McAndrews, Director, NEA/INR; Hal Ford OPR/CIA; Dr. Robert Jones, OCI/CIA; W. Hutchinson, NTO (Saudi Arabia). In addition, presentations have been made to MORS and Defense Intelligence School (as a course exercise in estimates).

- Developed preliminary versions of country-specific decision modules. These modules are designed to reflect actual bureaucratic structures within the relevant governments. Some of the theoretical issues underlying these modules are discussed in PTP Working Papers 1,3,4,6,8,9,10,12,13,14,18,20,21,and 22.

- Developed software and displays to run entire simulation interactively. This involved the writing of a Terminal Monitor Program which, among other things, allows the user to change the structure of the program as well as simply changing variable values. This is of great use in obtaining immediate feedback from users during demonstrations.

- Preliminary identification of major policy objectives (domestic and foreign) of Iran, Saudi Arabia, Iraq, Libya and Algeria. These serve as "data" for the decision modules and were generated through analysis of public documents and budgetary allocations and expenditures. The procedures and results are described in PTP Working Paper 14.

- Developed event based simulation modules to demonstrate policy implications of that data source. These are described in PTP Working Papers 1,3,4,5,12,and 20.

- Developed routines for using interactive computer simulations to elicit goals and strategies from policy analysts. These are described in PTP Working Papers 11 and 24.

- Identified roles of forecasting in policy planning. These are described in PTP Working Papers 2, 11, 24, and 25.

- To date, there have been twelve papers produced under this contract which have been accepted for publication in professional books and journals. Numerous presentations of work stemming from the Project have been made within both the academic and policy communities. In addition twenty-five Working Papers have been written which describe various aspects of the Project.

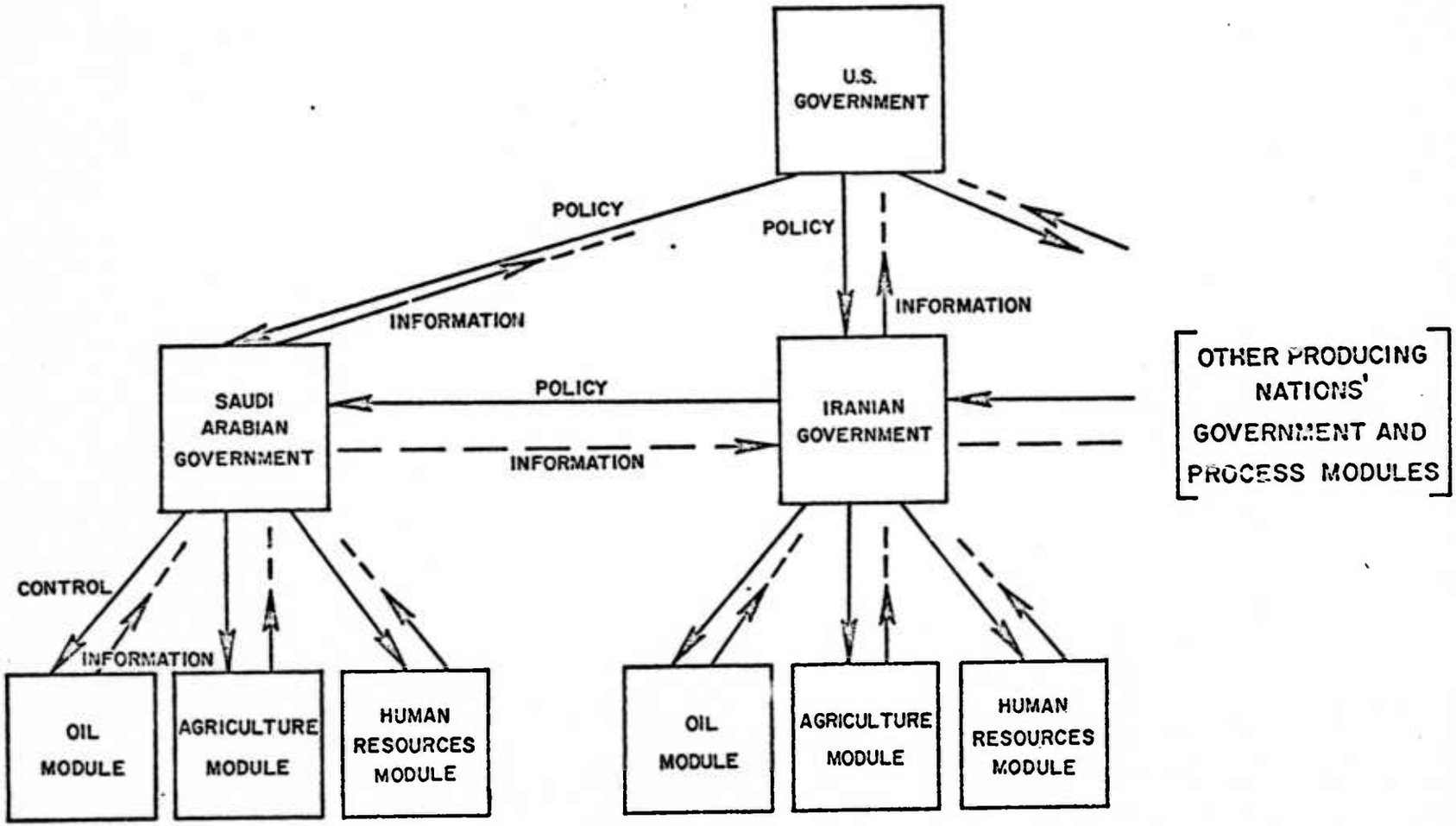


Figure I-1 Overall Structure of the Simulation

II. OIL MODULE

The Project presently has available on a stand-alone basis, a running simulation module for the oil industry in Saudi Arabia. It consists of three "stages", each of which represents a specific time period.

The first "stage" is used for the years 1963-1972, and although it makes no attempt to model explicit country-company relationships, it provides values for Saudi Arabia's income from oil revenues for those years. It determines the monthly revenue for any given month of that period by taking one-twelfth of Saudi Arabia's revenue for the appropriate year. The annual revenue figures are taken directly from Table 95 of the OPEC Statistical Bulletin for 1972. The primary purpose of the first stage is to provide revenue data which permit testing other simulation modules over the 1963-1972 time period.

The second stage models country-company relationships for the year 1973. Revenues resulting from the sales of independent and sellback crude are kept distinct from tax and royalty revenues, and the Saudi government's growing control over production capacity, production level, and prices is included in the stage.

The third stage simulates the period beginning January 1974. In this stage, the producing country government sets production levels and prices unilaterally, disregards entirely the Teheran, Geneva I and Geneva II agreements, and determines its own share of participation. It is anticipated that this third stage is flexible enough to permit simulation of various alternate futures through simple changes in its parameters. This third stage is a recent modification, and represents changes made to reflect events of the six to nine months.

Research Report Number 23 provides an interim user's manual for the Oil Module in its present stand-alone form, and includes examples of needed user input and suggestions for the simulation of recent events. Figures II-1 and II-2 illustrate the logical structure of this module.

FIGURE II-1

Simple Flowchart of Computer Program

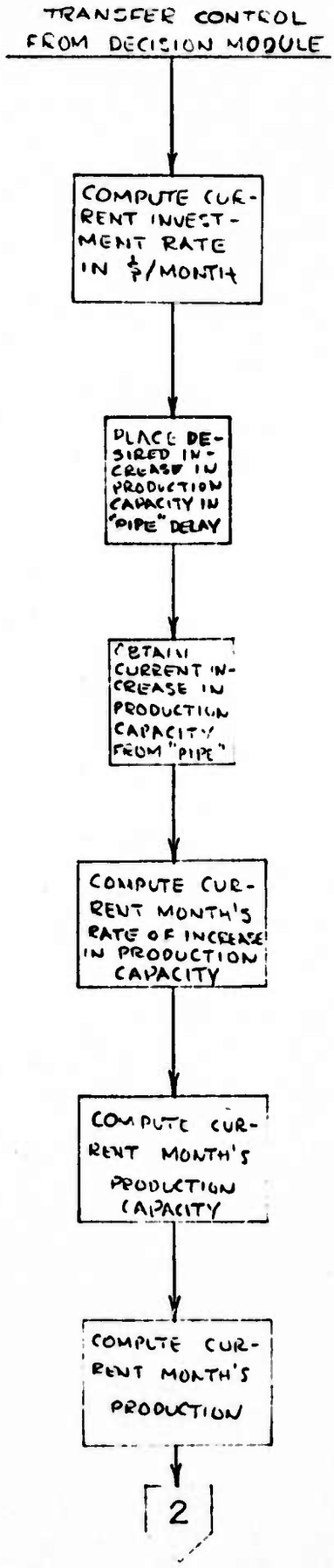


FIGURE II-1 (cont.)

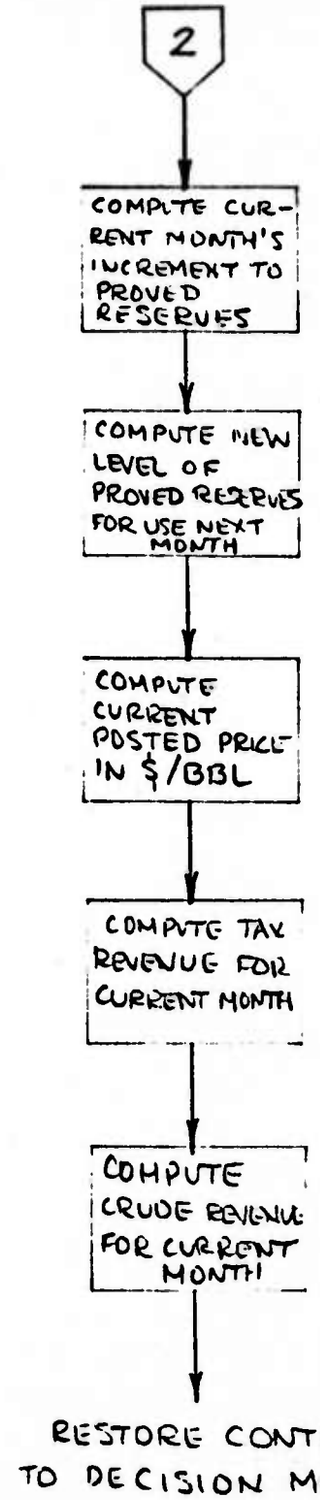
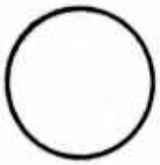
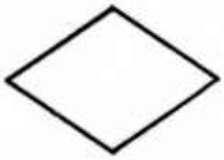


FIGURE II-2a

Legend for symbols used in Figure II-2b:



Process information variable



Control information from control stratum

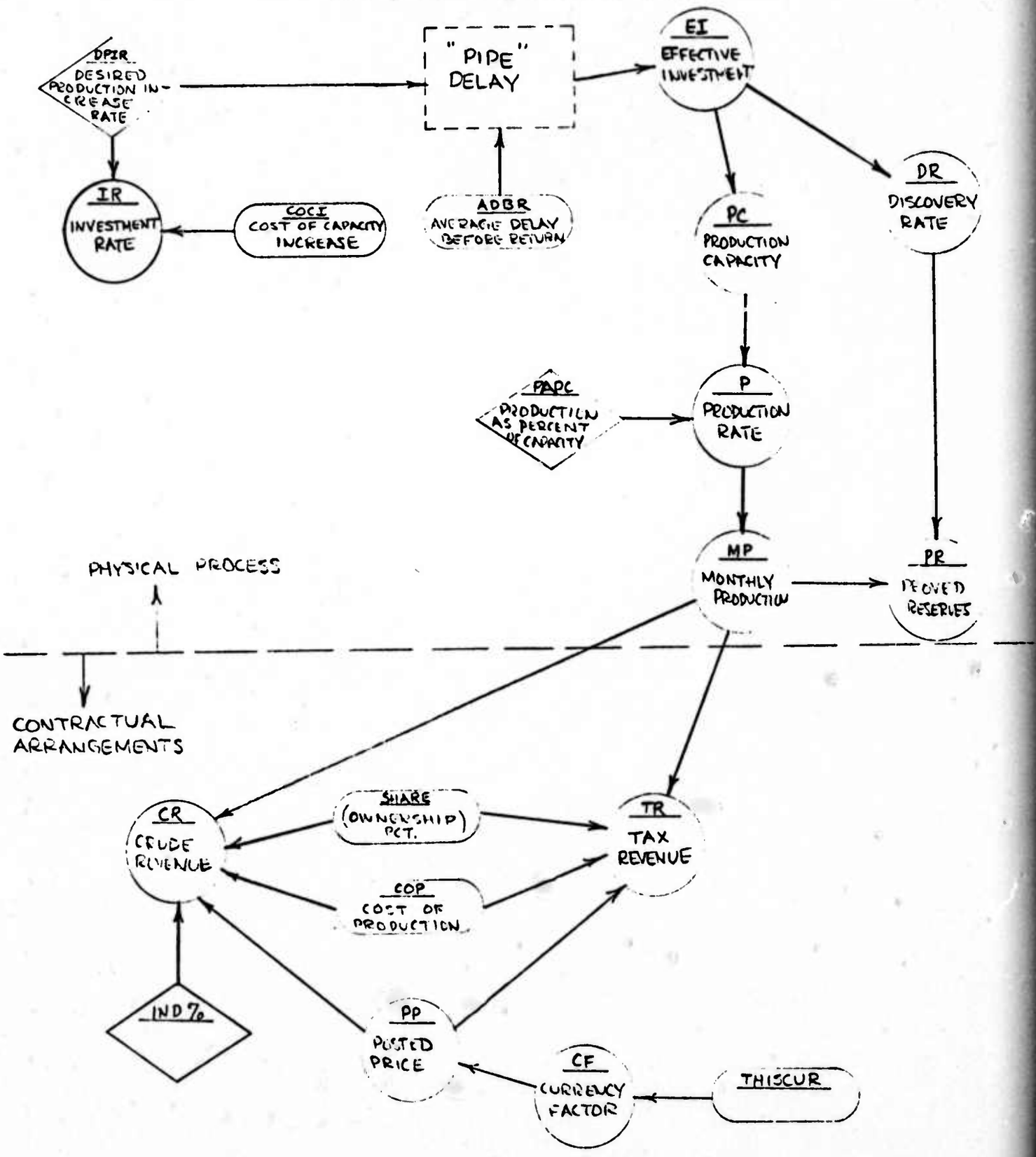
Exogenous information provided by user

Indicates influence of one variable upon another

Specifics additional detail concerning a particular influence mechanism

FIGURE II-2b

Conceptual Flowchart of Module



III. DECISION MODULE

The goal of the project is the development of forecasting techniques to the point where alternative United States policies towards specific countries can be unambiguously ordered with respect to their utility in light of certain U.S. national objectives. As a means for attaining that goal, complex simulations of five Middle Eastern countries are being developed. The simulations consist of four modules. The oil, agriculture, and human resource modules are designed to reflect the environment that the decision makers in the various countries face. The modules describe the effects of particular actions by the decision makers, as well as the actions that are available. In order to be in a position to evaluate the effectiveness of alternative U.S. policies toward these countries, we must know how the five Middle Eastern countries can be reasonably expected to behave. The purpose of the decision module is to give reasonable projections of the behavior of these countries (both foreign and domestic) in light of: 1) actions by the United States; 2) actions of other countries; and 3) changing "environmental" conditions, e.g., demand for oil, draught, etc. There are an infinite number of different behaviors (inputs to the three modules) that a country could exhibit (investment in agriculture, fertilizer usage level, oil production level, et cetera). The decision module must be able to determine which inputs each of the five countries can be expected to choose. The sector modules represent the choices--the decision module must make them. In addition to domestic sorts of behaviors, the decision modules must be able to reflect those foreign policy behaviors that the countries could be reasonably expected to exhibit.

Our efforts to specify working decision modules for the five oil producing Middle Eastern nations has been directed at several issue clusters: 1) properties of goal directed systems; 2) properties of multi-goal seeking systems; and 3) properties of linkage between the environment and the decision module. The country specific decision modules must have the capability of perceiving the relationship between current environmental states (e.g., amount of oil production, labor supply, the behavior of other nations, et cetera) and the goals of the decision system. Based upon this perceived environment, the decision module must have the capability of "deciding" actions that are expected to increase the level of goal attainment. Once the "decision" has been made, the system must have the capability of executing the particular actions. In addition, our concern with the reflection of existing bureaucratic structures necessitates that the internal decision process of the decision module be capable of distinguishing internal actors (bureaucracies and ministries), their preferences, the issues they see as relevant, and their interaction.

In order to construct a structure that has the capability of exhibiting those properties that we feel must characterize the decision modules, we have exerted considerable effort in the specification of a language appropriate for the expression of the modules. This notion of language is used in two senses. The first refers to the theoretical language in which we describe the decision process within each of the five countries. As is discussed in Research Report 20, this theoretical use of language gives us the power and capability through the use of production systems, to specify, model, and monitor internal bureaucratic activities in the various nations. In addition to its role as a medium for expressing our theoretical structure for national behavior. The second use

of language is the medium through which the countries perceive the environment and through which the countries execute commands, i.e., behavior intended to increase goal attainment.

This specification of the issues and the proposed structure for their resolution is elaborated in Research Report 20, "A Discussion of Issues in Need of Resolution: Toward a Specification of the Decision Module."

IV. METHODOLOGY AND PROGRAMS

4.1 : Computer Terminals. The Ohio State University's simulation capabilities are strongly facilitated by TSO (Time Sharing Option) terminal capability. In order to make the most use out of this capability the Project has rented 3 computer terminals. One Execuport produces a standard 80 column hard copy and can be easily transported to and from Washington in demonstrating the modular simulations being produced on the project. Two other terminals are CRT's. These are excellent for debugging simulation programs and running the simulations when volumes of hard copy are not essential. Of course, separate commands for producing hard copy at the computer terminal for any run on the CRTs is available. Primary responsibility for developing and maintaining our computer system is provided by Polimetrics Laboratory at Ohio State University.

4.2 Terminal Monitor Program

The Project for Theoretical Politics presently has under development a terminal monitor program (TMP) for the Ohio State University Instruction and Research Computer Center's TSO (time sharing) system. The TMP is being developed by James M. Ludwig of the Polimetrics Laboratory of the Department of Political Science. This paper will give a brief statement of why this course of action (developme t of a TMP) was selected and what the program's present status is.

There are several reasons why the TMP program was undertaken. First, it was pointed out in earlier Project papers that in the oil module it will likely be necessary for the user to write a short program of his own and incorporate it into the module in order to explore the consequences of scenarios not presently available within the module. This is necessary because in the oil module alternate scenarios generally involve alternate logical structures and not simply different sets of parameter values. Unfortunately, however, permitting the user to write and incorporate even a brief program into the module is not a trivial task. Especially important is the fact that within the PL/I language there is no facility for checking, in advance of when the program is actually needed, to see if the user has in fact supplied the program he said he would and linked it properly to the primary module. If the user-supplied program was inadvertently not supplied or was improperly linked, the oil module will "crash" whenever it requests the user-supplied program. If the "crash" occurs well into a simulation run, much time, effort, and money will have been wasted. With a custom-written terminal monitor program, checks may be made to insure the existence of a user supplied program before the simulation beings its run.

Second, it is anticipated that development of the decision module will require much trial-and-error, both in the area of program revision and in the area of program debugging. Repeated compilation (which would be required in this process) is extremely time-consuming, and it is a characteristic of the normal TSO TMP that when one program (the compiler, say) is executing no other tasks may be undertaken by the user. All tasks are executed sequentially. This is extremely wasteful of the research staff's time and places severe constraints upon how much useful development work can be accomplished in a given day. The PTP TMP permits tasks to be run concurrently and independently, so that a researcher could edit a dataset, say, while a revised program was being compiled. This should result in a sizeable increase in efficiency.

Third, the PTP TMP will permit the various simulation modules to dynamically allocate and/or free datasets while the programs are executing and under program control.

Finally, the TMP will permit various kinds of monitoring of PTP programs in order to improve execution efficiency, and will also yield considerably faster response time in the execution of commands and CLISTS from private libraries. The user interface with the overall PTP simulation will likely make use of a relatively large private library of commands and CLISTS.

STATUS

At present, the user may use the PTP TMP to

1. run tasks concurrently and independently through the the attachment of subtasks;

2. execute large numbers of private commands with increased efficiency; and

3. perform limited usage monitoring of users.

Further development of the program had been stalled until the recent solution of a very difficult problem involving the handling of attention interrupts when subtasks were attached. The solution to the attention interrupt problem necessitated substantial changes in the architecture of the program, which is presently being re-assembled by Jim Ludwig. When the new version is available for use, it will be of considerably more use in the day-to-day development tasks of the Project.

V. DATA

5.1 : Data Acquisition. In an attempt to have on hand a complete file on national attributes the project has acquired and implemented the Minnesota Data Set and Retrieval Program. These data were collected under the auspices of MUCIA.

VI. PERSONNEL

6.1 Principal Investigators

Professor Thorson has been monitoring the development of the oil and agriculture modules and involved in the development of country specific decision modules. He represented the Project at the annual meetings of the International Studies Associaition, the Pittsburgh Modeling and Simulation Symposium, and the Midwest Political Science Association and the Indiana Mini-Conference on Control Theory and the Social Sciences.

Dr. Phillips has spent a good deal of his time in extending the policy-maker's base upon which the contract rests. He has also spent time in Columbus assisting in the development of the agriculture and oil modules. He has developed a working relationship with those offices responsible for national estimates in Saudi Arabia and Iran. He expects to use the models for each country to produce an estimate of U.S. oil relations with each country. He has made presentations to:

1. M. General W. Smith, AFXDOC
2. Futures Group, Strategic Studies Institute, Carlisle Barracks
3. Office of Political Research, CIA
4. Office of Research Development, CIA
5. Office of Current Intelligence, CIA
6. Defense Intelligence School
7. INR/NEA

and has established working relations with:

1. INR/NEA
2. NIO level in National Estimates Joint DIA, CIA, INR support.
3. FMS/NEA/ISA

Paul Anderson, Terry Buss, and Phil Miller, graduate students associated with the project, each reported on various project related results at the Midwest Political Science Association Meetings, (see Working Papers 21 and 22).

VII. PUBLICATIONS AND WORKING PAPERS (since last semi-annual technical report)

7.1 Working Papers

No. 20 Anderson, P.A. "A Discussion of Issues in Need of Resolution: Toward a Specification of the Decision Module"

No. 21 Anderson, P.A. and Miller, P.L. "Why War: A Mathematical Systems Approach"

No. 22 Buss, T.F. "Dimensionality and Spatial Modelling: A Critical Assessment"

No. 23 Crain, R.C. "Interim User's Guide for the Oil Module"

No. 24 Phillips, W.R. and Thorson, S.J. "Simulation for Policy Planning"

No. 25 Thorson, S.J. "The Inter-Nation Simulation Project: A Methodological Appraisal"

7.2 Publications

No. 11 Phillips, W.R. and Thorson, S.J. "Simulation for Policy Planning" forthcoming in the Fifth Annual Pittsburgh Conference on Modeling and Simulation Proceedings

No. 12 Thorson, S.J. "The Inter-Nation Simulation Project: A Methodological Appraisal" in Quantitative International Politics: An Appraisal (Sage Publication, forthcoming)

VIII. BUDGET

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8.2	Expenditures and Committments to date	$142,747.18
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